Comment on "New Limits to the Infrared Background: Bounds on Radiative Neutrino Decay and on Contributions of Very Massive Objects to the Dark Matter Problem"

Recent observations of TeV γ rays from the active galaxies Markarian 421 and 501 have provided new limits on the cosmic background of infrared photons which are an efficient opacity source due to the pair process $\gamma_{\rm TeV}\gamma_{\rm infrared} \to e^+e^-$. In a recent Letter [1] these limits were interpreted, *inter alia,* as limits on the radiative decay of cosmic background neutrinos with sub-eV masses. However, it was overlooked that in this mass range, much more restrictive limits on neutrino radiative decay channels already exist, preventing neutrino decays from contributing significantly to the infrared background.

Neutrinos can have a variety of different electromagnetic form factors. A radiative decay process $\nu_2 \to \nu_1\gamma$ (masses m_2 and m_1, respectively) is uniquely characterized by the magnetic and electric transition moments μ_{21} and ϵ_{21} according to

$$\Gamma_{\nu_2\to\nu_1\gamma} = \frac{|\mu_{21}|^2 + |\epsilon_{21}|^2}{8\pi}\left(\frac{m_2^2 - m_1^2}{m_2}\right)^3 = 5.308\ {\rm s}^{-1}\left(\frac{\mu_{\rm eff}}{\mu_{\rm B}}\right)^2 \delta_m^3 m_{\rm eV}^3\,, \qquad (1)$$

where $\mu_{\rm eff}^2 = |\mu_{21}|^2 + |\epsilon_{21}|^2$, $\mu_{\rm B} = e/2m_e$ is the Bohr magneton, $m_{\rm eV} = m_2/{\rm eV}$, and $\delta_m = (m_2^2 - m_1^2)/m_2^2$. This latter quantity is approximately unity unless the neutrino masses are nearly degenerate. The neutrino radiative lifetime limits based on the cosmic photon backgrounds [1,2] thus provide exclusion regions in the $\mu_{\rm eff}$-m_ν plane (Fig. 1), assuming a mass hierarchy $m_\nu = m_2 \gg m_1$, i.e., taking $\delta_m \approx 1$.

Neutrino dipole and transition moments are also constrained to avoid excessive stellar energy losses by the plasmon decay process $\gamma \to \nu\overline{\nu}$, an idea going back to Ref. [3], with more recent refinements in Refs. [4–6]. For neutrino masses below a few keV the limit is $\mu_{\rm eff} \lesssim 3\times10^{-12}\mu_{\rm B}$, shown as a hatched bar across Fig. 1. (For Dirac neutrinos the limit would be slightly more restrictive because the number of final states in $\gamma \to \nu\overline{\nu}$ doubles.) The m_ν^3 phase-space factor in Eq. (1) is so punishing that the direct radiative decay limits quickly become irrelevant for $m_\nu \lesssim 2$ eV. The recent indications for neutrino masses from the solar and atmospheric neutrino anomalies, the liquid scintillator neutrino detector (LSND) experiment, and the cosmological hypothesis of hot plus cold dark matter suggest that neutrino masses are indeed below 1–2 eV.

Therefore, unless something is unexpectedly wrong with the globular-cluster limit, radiative neutrino decays cannot produce infrared background photons at the level of current detection limits. Interpreting measurements of photon backgrounds as constraints on radiative neutrino decays is still important, of course, as it is an independent method with other experimental and theoretical uncertainties than the stellar-evolution arguments.

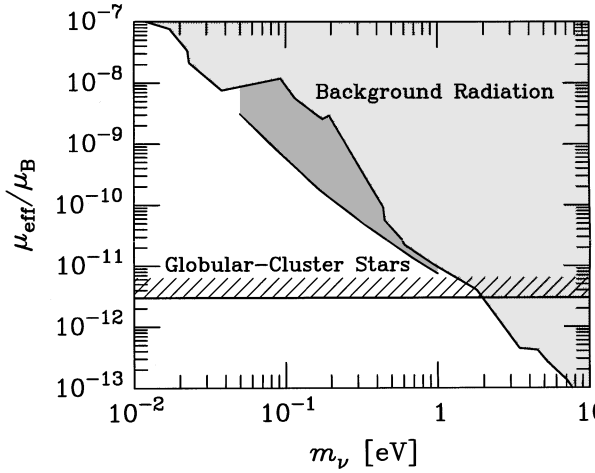

FIG. 1. Exclusion range for neutrino transition moments. The light-shaded region was previously excluded from the contribution of radiatively decaying neutrinos to the cosmic photon background radiations [2]; the dark-shaded region is the new exclusion range from the infrared background, case 10 TeV [1]. Values above the hatched bar are excluded from the plasmon decay process in globular-cluster stars [4–6].

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[1] S. D. Biller *et al.*, Phys. Rev. Lett. **80**, 2992 (1998).
[2] M. T. Ressell and M. S. Turner, Comments Astrophys. **14**, 323 (1990).
[3] J. Bernstein, M. A. Ruderman, and G. Feinberg, Phys. Rev. **132**, 1227 (1963).
[4] G. G. Raffelt, Astrophys. J. **365**, 559 (1990); Phys. Rev. Lett. **64**, 2856 (1990).
[5] M. Catelan, J. A. de Freitas Pacheco, and J. E. Horvath, Astrophys. J. **461**, 231 (1996).
[6] G. Raffelt, *Stars as Laboratories for Fundamental Physics* (Chicago University Press, Chicago, 1996).

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